CLAIMS

1. An ultra low NOx burner for process heating, comprising:

a) a fluid based flame stabilizer which can provide a fuel-lean flame at equivalence ratio in the range of phi = 0.05 to phi = 0.3; and

b) a plurality of fuel staging lances surrounding said flame stabilizer, each said lance comprising a pipe having a staging nozzle at a firing end thereof, each lance having at least one hole for staging fuel injection, each hole having a radial divergence angle and an axial divergence angle;

whereby NOx emissions of less than 9 ppmv are generated at near stoichiometry conditions.

2. The ultra low NOx burner for process heating of claim 1, wherein said at least one hole and said divergence angles are adapted to provide complete circumferential coverage of the fuel-lean flame.

3. The ultra low NOx burner for process heating of claim 1, wherein said at least one hole and said divergence angles are adapted to provide a flat flame pattern.

4. The ultra low NOx burner for process heating of claim 1, wherein said at least one hole and said divergence angles are adapted to provide a load shaping flame pattern

5. The ultra low NOx burner for process heating of claim 1, wherein the plurality of fuel staging lances comprises between 4 and 16 staging lances per flame stabilizer.

6. The ultra low NOx burner for process heating of claim 1, wherein each staging nozzle has between 1 hole and 4 holes.

7. The ultra low NOx burner for process heating of claim 1, wherein the radial divergence angle is between 8° and 24°.

8. The ultra low NOx burner for process heating of claim 1, wherein the axial divergence angle is between 4° and 16°.

9. The ultra low NOx burner for process heating of claim 1, wherein the nozzle is adapted to allow fuel to exit the nozzle at from 300 to 900 feet per second for natural gas staging fuel.

10. The ultra low NOx burner for process heating of claim 1, wherein the fluid based flame stabilizer is a large scale vortex device.

11. The ultra low NOx burner for process heating of claim 1, wherein the large scale vortex device is adapted to provide a fuel-lean flame that has a peak flame temperature of less than approximately 2000° Fahrenheit.

12. The ultra low NOx burner for process heating of claim 1, wherein the equivalence ratio is in the range of phi = 0.05 to phi = 0.1.

13. The ultra low NOx burner for process heating of claim 1, wherein a distance from the forward end of the burner to a point where mixing of staging flame and flame stabilizer flame occurs is approximately 8 to 48 inches.

14. The ultra low NOx burner for process heating of claim 1, wherein the fuel rate of the staging for natural gas fuel is from 70% to 95% of the total fuel firing rate of the burner.

15. The ultra low NOx burner for process heating of claim 1, including a burner block coaxial to said flame stabilizer.

16. The ultra low NOx burner for process heating of claim 15, wherein the burner block is slightly conical in shape.

17. The ultra low NOx burner for process heating of claim 15, wherein the burner block is rectangular in shape.

18. An ultra low NOx burner for process heating, comprising:

a) a fluid based flame stabilizer in the form of a large scale vortex device which can provide a fuel-lean flame at equivalence ratio in the range of phi = 0.05 to phi = 0.3; and

b) between 4 and 16 fuel staging lances per flame stabilizer adjacent to said flame stabilizer, each said lance comprising a pipe having a staging nozzle at a firing end thereof, each lance having between one and four holes for staging fuel injection, each hole having a radial divergence angle and an axial divergence angle;

whereby NOx emissions of less than 9 ppmv are generated at near stoichiometry conditions.

19. The ultra low NOx burner for process heating of claim 18, wherein the fuel staging lances surround said flame stabilizer and the at least one hole and the divergence angles are adapted to provide complete circumferential coverage of the fuel-lean flame for circular staging.

20. The ultra low NOx burner for process heating of claim 18, wherein the fuel staging lances are positioned in a linear fashion in single or multiple rows on either side of the flame stabilizer and wherein the at least one hole and the divergence angles are adapted to provide a flat flame profile.

21. The ultra low NOx burner for process heating of claim 18, wherein the fuel staging lances are positioned in a linear fashion in single or multiple rows on either side of the flame stabilizer and wherein the at least one hole and the divergence angles are adapted to provide a flame confined between two parallel flat planes.

22. The ultra low NOx burner for process heating of claim 18, wherein the fuel staging lances are positioned in a geometrical fashion and almost parallel to a load geometry in a single or multiple rows and close to the flame stabilizer and wherein the at least one hole and the divergence angles are adapted to provide a flame confined between two parallel flat planes.

23. The ultra low NOx burner for process heating of claim 18, wherein the radial divergence angle is between 8° and 24° and the axial divergence angle is between 4° and 16°.

24. The ultra low NOx burner for process heating of claim 18, wherein the nozzle is adapted to allow fuel to exiting the nozzle at from 300 to 900 feet per second for natural gas staging fuel.

25. The ultra low NOx burner for process heating of claim 18, wherein the large scale vortex device is adapted to provide a fuel-lean flame that has a peak flame temperature of less than approximately 2000° Fahrenheit.

26. The ultra low NOx burner for process heating of claim 18, wherein the equivalence ratio is in the range of phi = 0.05 to phi = 0.1.

27. The ultra low NOx burner for process heating of claim 18, wherein a distance from the forward end of the fuel pipe of the flame stabilizer to a point where mixing of staging flame and flame stabilizer flame is approximately 8 to 48 inches.

28. The ultra low NOx burner for process heating of claim 18, wherein the fuel rate of the staging for natural gas fuel is from 70% to 95% of the total fuel firing rate of the burner.

29. The ultra low NOx burner for process heating of claim 18, including a burner block coaxial to said flame stabilizer.

30. The ultra low NOx burner for process heating of claim 29, wherein the burner block is slightly conical in shape.

31. The ultra low NOx burner for process heating of claim 29, wherein the burner block is rectangular in shape.

32. The ultra low NOx burner for process heating of claim 18, wherein a separation distance between individual fuel lances are from about 2 to 12 inches.

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